



Armed Forces College of Medicine

AFCM



Pulmonary Surfactant

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INTENDED LEARNING OBJECTIVES (ILO)



**By the end of this lecture the student will
be able to:**

1. Define surfactant & describe its functional structure.
2. List the physiological functions of the surfactant.
3. List factors affecting formation of the surfactant.

Alveolar surface tension & surfactant



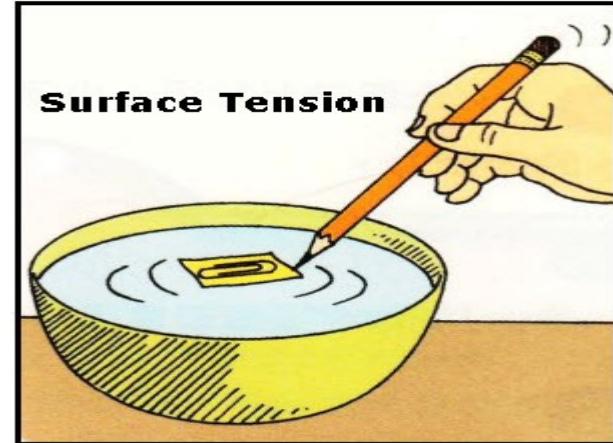
The attractive forces between H₂O molecules in the liquid film that lines the alveoli are responsible for



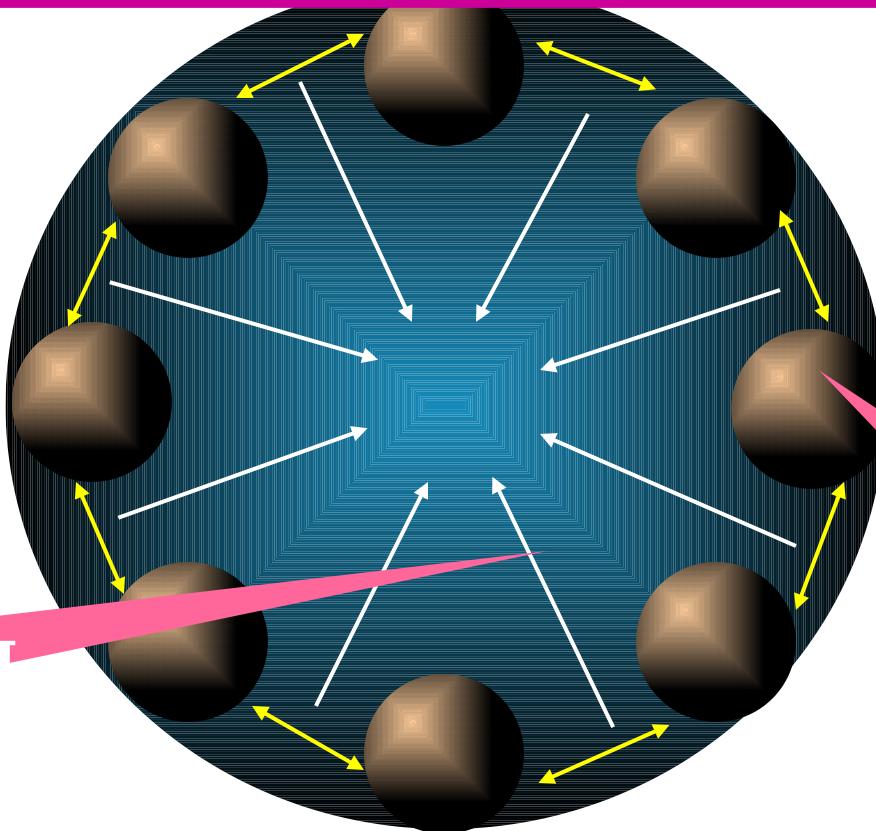
**Surface
tension** ↓ which



Tends to collapse alveoli &
resist their inflation.



Alveolar surface tension



An alveolus

The surface tension of water lining the alveoli

is reduced by the pulmonary surfactant

Alveolar fluid

Pulmonary surfactant is secreted by type II alveolar cells (granular pneumocytes)

Surfactant secreting cells

Pulmonary surfactant



■ Def:

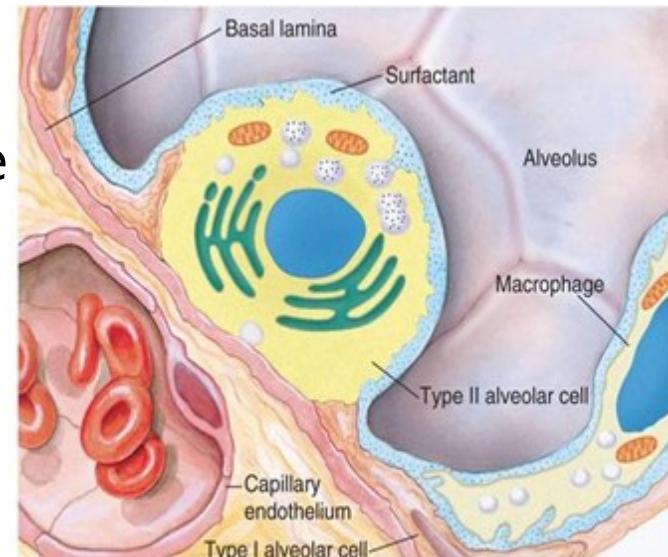
It is a surface tension lowering substance secreted by *type II alveolar epithelium* & spreads over the fluid surface of alveoli.

■ Structure:

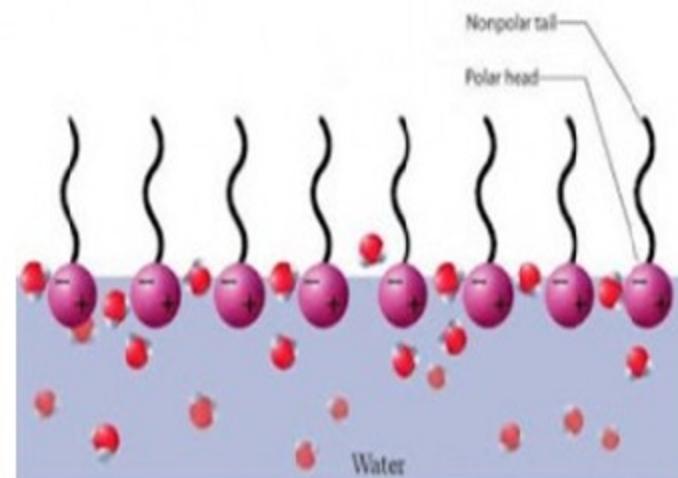
- It is a complex mixture of phospholipids (lecithin), proteins & Ca++ ions.
- It has
 - A **hydrophilic end** (towards the fluid lining alveoli)
 - A **hydrophobic end** (towards the air in the alveoli=lumen)

□ this separates the surface H₂O molecules □ ↓ the attractive forces between them □ ↓ surface tension

- Surfactant formation starts after **24th** weeks of intrauterine life & completed at **35th** week so full term, cortisol, thyroxine & oxygen are needed for full surfactant formation.

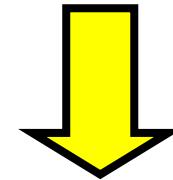
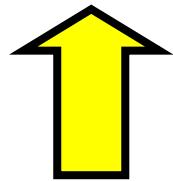


<https://owlcation.com>



<https://personalcaretruth.com>

:Factors affecting surfactant formation



Full term

Adequate oxygen supply

Hormones e.g cortisol, thyroxine

Pre-maturity

Hypoxia

**Hypothyroidism,
Hypocortisolism,
Hyper-insulinism**

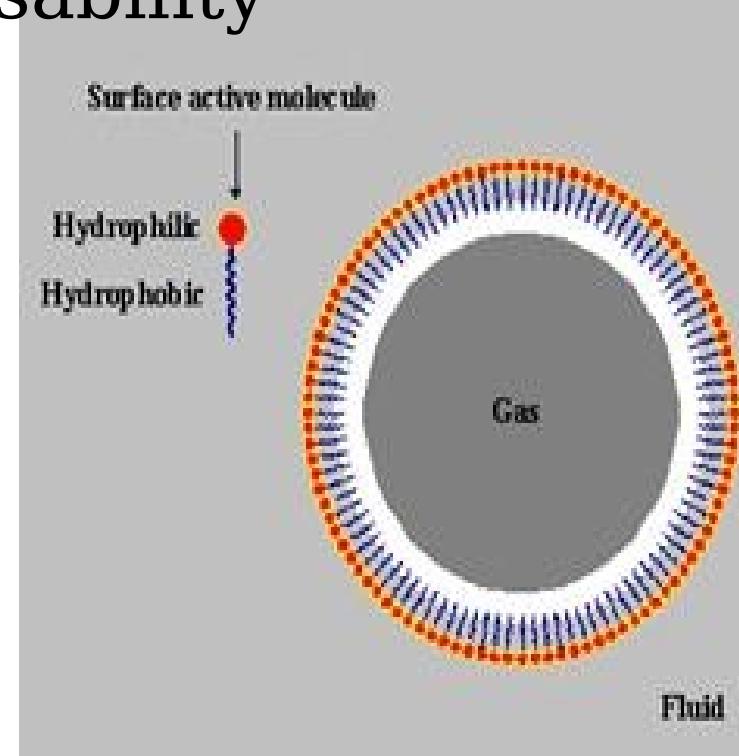
Heavy smoking

Lung diseases

:Physiological importance of surfactant

1- Lowering of surface tension in alveoli:

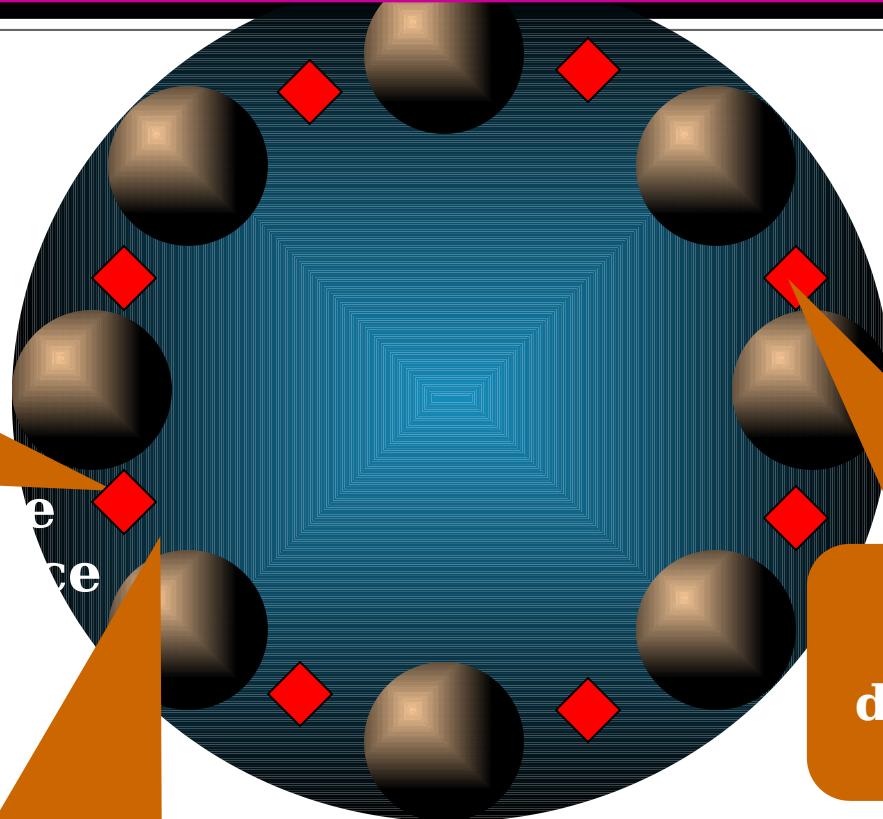
- ↓ recoil force of the lungs.
- ↑ lung expansion & dispensability (compliance).
- **Because** it has a hydrophilic end in the fluid lining alveoli & a hydrophobic end in the air in the alveoli so it separates the surface H₂O molecules □ ↓ the attractive forces between them □



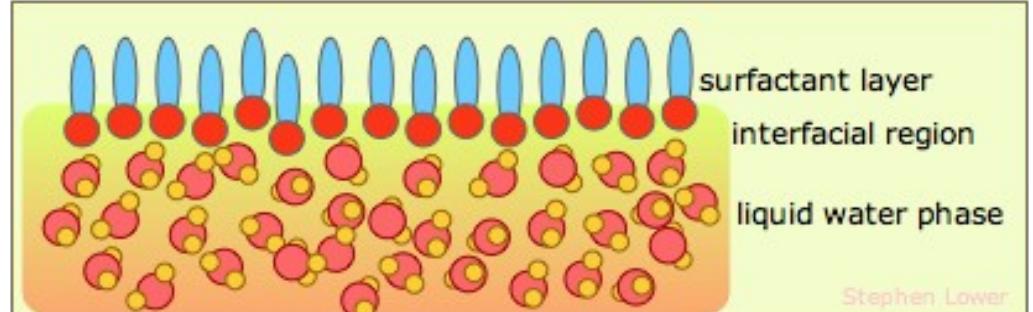
Surfactant molecules intersperse between water molecules

Surfactant molecules at the gas-liquid interface

Surfactant form a layer between the fluid lining alveoli & air in the alveoli

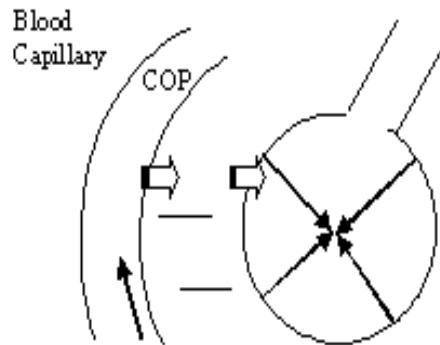


So surfactant decreases the surface

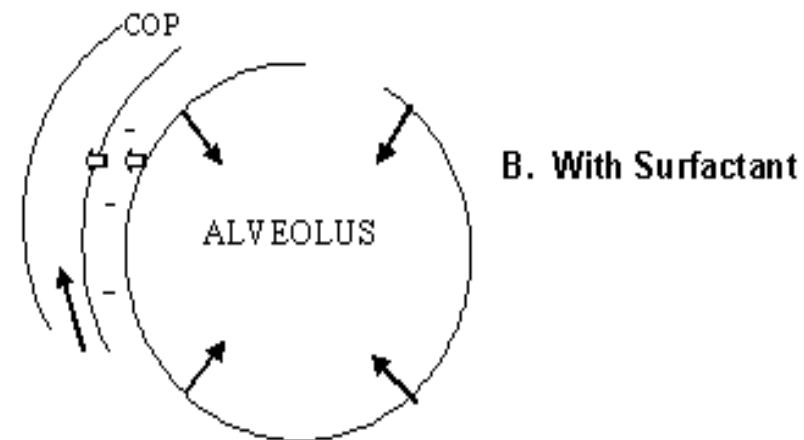


:Physiological importance of surfactant

2- Keeping alveoli dry & prevent pulmonary edema



A. Without Surfactant



B. With Surfactant

Absence of surfactant

- ↑ surface tension of the alveolus.
- resulting in more fluid filtering out of the capillaries into the

Surfactant

- ↓ surface tension.
- preventing fluid from leaving the capillaries and keeping the alveoli dry.

:Physiological importance of surfactant

3- Stabilization of alveolar size & preventing lung collapse:

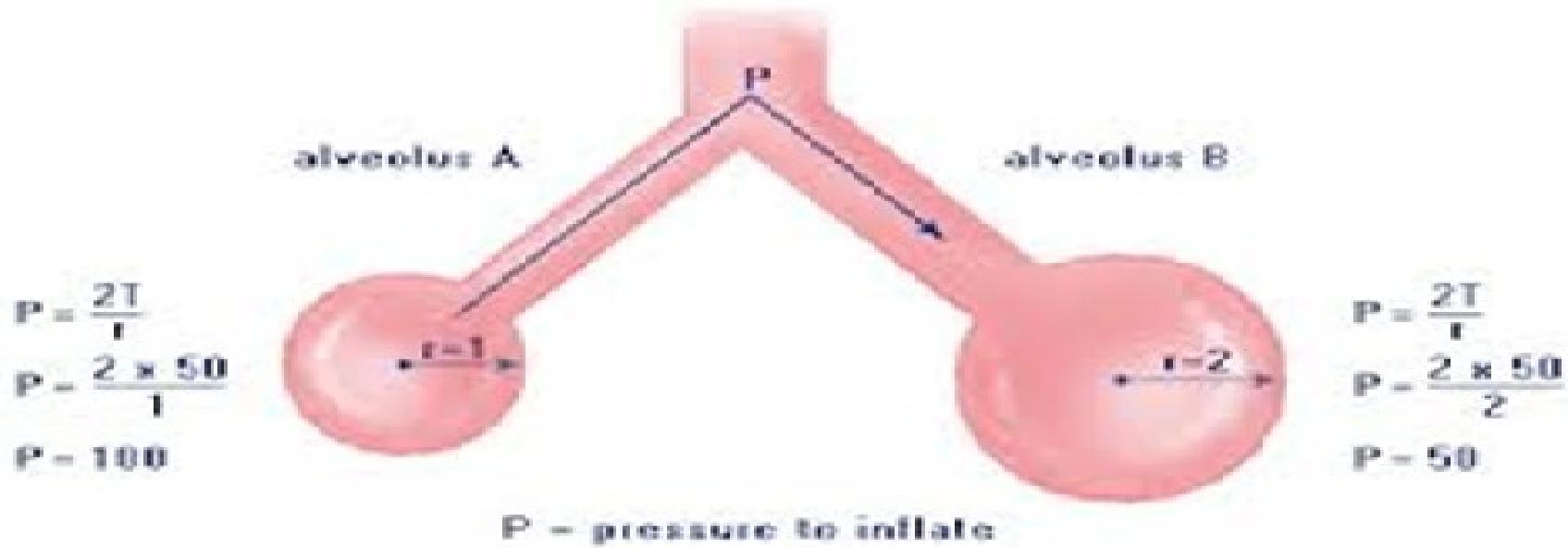
This can be explained by Laplace law which states that:

"The pressure inside an alveolus (P) is directly proportional with surface tension (T) and inversely proportional with the radius of the alveolus (r)."
P = Inward collapsing pressure

T = Surface tension

r = Radius of alveolus

$$P = \frac{2T}{r}$$



P = pressure to inflate

<https://bodytomy.com>

- If we consider the tension is the same in the 2 alveoli. ($T=50$)
- Pressure in alveolus (A) which has a radius ($r = 1$) will be 100.
- Pressure in alveolus (B) which has a radius ($r= 2$) will be 50.
- So air will move from alveolus (A) to alveolus (B) causing (A) to collapse & alveolus (B) to get larger.
- To avoid that collapse & to keep size of alveoli constant, pressure must be constant.... Suppose it 50. how will this be?

Surfactant adjusts surface tension of an alveolus to match its size by ↓ing tension in smaller alveoli more than in larger one.

What will happen if the tension was the same in all alveoli??

If the surface tension is similar in small & large alveoli → the small alveoli will collapse & empty their air into the larger ones.

Why does the surfactant exert stronger effect in smaller than in larger alveoli?

Because the surfactant molecules are closer together in the small alveoli. i.e more concentrated

Aim: to ↓surface tension more so prevent the smaller alveoli from collapse.

Law of LaPlace

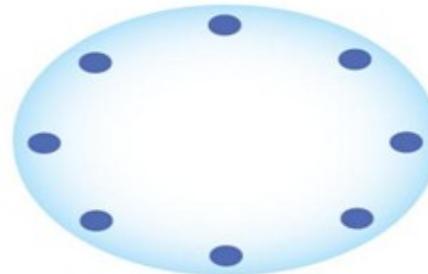
Law of LaPlace: $P = 2T/r$

P = pressure

T = surface tension

r = radius

According to the law of LaPlace, if two bubbles have the same surface tension, the small bubble will have higher pressure.



(b) Surfactant reduces surface tension (T). Pressure is equalized in the large and small bubbles.

Because the collapsing pressure is inversely proportional to the radius, the small alveoli tend to collapse.

This collapse is prevented by reduction in the surface tension brought about by the pulmonary surfactant.

Respiratory distress syndrome

(Hayline membrane disease)

Deficiency
of
surfactant

Increased
Surface tensi
forces

Decreased
Lung
Compliance
alveolar co

Respiratory i
Pulmonary e
and dea

A patient
with
respiratory distress
syndrome will have

Increased
work
of breathing

A deficiency of
monary surfactant in infants
is responsible for

Newborn
respiratory distress
syndrome

Common in premature infants

Treated by

- 1- Replacement therapy : inhalation of synth
- 2- Forcing air in baby's lung

[others who are liable to premature delivery
should be given **Glucocorticoids (cortisone)**

A deficiency of
monary surfactant in adults
is responsible for

Adult
respiratory distress
syndrome

Common in conditions that interfere with surfactant
&activity as:

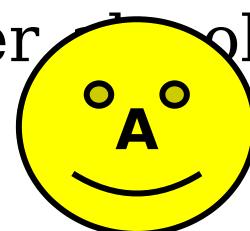
- 1- Hypoxia.
- 2- Inhalation of 100% O₂ for long time.
- 3- Patients undergoing prolonged operations (cardiac surgery).
- 4- Smoking.
- 5- Occlusion of one pulmonary artery or main bronchus.

ted by assisted ventilation, diuretics & glucocortico

Lecture Quiz



Which of the following is true about pulmonary surfactant?

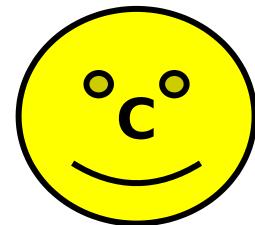
- a. It decreases the surface tension in smaller alveoli more than in larger ones 
- b. It is secreted by capillary endothelial cells.
- c. It is normally decreased in normal newborn babies.
- d. It is more concentrated in large alveoli to prevent their alveolar collapse.
- e. It causes more fluid filtering out of the capillaries into the interstitial space & into alveoli

Lecture Quiz



Concerning lung surfactant, all the following are correct, except:

- a. It increases lung compliance .
- b. It prevents pulmonary oedema .
- c. It increases the surface tension of the fluid lining the alveoli.
- d. In the absence of normal surfactant there will be greater tendency for alveoli to collapse.
- e. It decreases by long term inhalation of 100% oxygen.

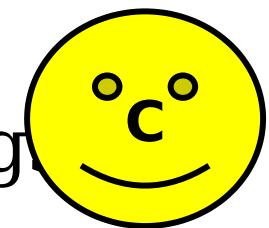


Lecture Quiz



Which of the following statements concerning pulmonary surfactant is correct?

- a. is secreted by type I alveolar cells.
- b. decreases the compliance of the lung.
- c. helps to keep the alveoli dry.
- d. is more concentrated in the large alveoli.
- e. increases the filtration from pulmonary capillaries .
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SUGGESTED TEXTBOOKS



- 1. Ganong's Review of Medical Physiology. 23rd edition , chapter 35, page (596, 597)**
- 2. Kaplan Medical USMLE step 1 lecture notes.**
- 3. Guyton & Hall: Textbook of Medical Physiology, 12e, pages 876 &877**
New Five-Year Program Cardio-pulmonary Module



A pixelated illustration of a brown teddy bear sitting on the left, facing right. It has a white bow tie and a small red heart on its chest. In its right paw, it holds a heart-shaped cookie decorated with white frosting and a red heart. To the right, a large, semi-transparent purple heart-shaped banner with a white outline and a subtle gradient is displayed. The word "Thank You" is written in a white, cursive, sans-serif font across the center of the banner.

Thank You